Appendix C

Micropurge Study

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C-1. INTRODUCTION

Obtaining representative groundwater samples is a critical mission at the Idaho National Engineering and Environmental Laboratory (INEEL) where groundwater contaminants may pose a risk to human health or the environment. Groundwater-monitoring wells serve as access points through which to sample and characterize an aquifer. However, obtaining a water sample from a monitoring well that is truly representative of the formation groundwater is problematic. Water that is allowed to stand in a well casing can undergo changes in chemistry and become stagnant, due to events that can result in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration. In order to obtain a representative groundwater sample from a monitoring well, it is generally accepted that one must first remove (i.e., purge) the stagnant well water prior to sample collection (Robin and Gillham 1987; Keely and Boateng 1987).

For more than twenty years, the way in which groundwater-monitoring wells are purged prior to sample collection has been thoroughly studied and debated. The traditional method of purging groundwater-monitoring wells is to remove a fixed volume of water—typically, 3 to 5 times the volume of water standing in the well casing. This method, along with measuring stabilization parameters (e.g., pH, temperature, conductivity, dissolved oxygen), is arguably sufficient to remove stagnant water and produce representative groundwater for sample collection. However, many workers have raised the concern that sample integrity may be compromised by purging groundwater-monitoring wells at flow rates that greatly exceed the natural flux of groundwater through the well screen. Additionally, the requirement to remove 3 to 5 well volumes can result in the production of tremendous amounts of purge water that must be handled at the surface, which poses problems such as lengthy purge duration, worker exposure to potentially hazardous materials, and proper treatment and disposal of contaminated purge water (if required).

An alternative to traditional purging is to remove water at a very low rate directly adjacent to the well screen such that the overlying stagnant water is not pulled into the sampling device. This method is commonly termed micro-purging. However, a more popular term is "low-flow" purging. This method, if properly applied, can result in a dramatic increase in data quality and overall project costs.

C-1.1 Purpose and Scope

The purpose of this document is to discuss the possibility of commencing a low-flow groundwater monitoring well purging program for the INEEL's Waste Area Group (WAG) 10. Several studies have been conducted at the INEEL, which have directly or indirectly assessed low-flow purging at INEEL facilities. The primary objective of this document is to review existing INEEL studies in order to determine whether low-flow purging of WAG 10 groundwater-monitoring wells is supported by findings of these studies. Furthermore, many studies found in the literature have been performed regarding the applicability of low-flow purging at many different environmental sites. These studies comprise a vast foundation of scientific inquiry into the application of low-flow purging of groundwater-monitoring wells. A thorough review of these studies was conducted by Shanklin (2001), and will not be repeated in this document. This document presents a review of studies relating to low-flow purging of groundwater-monitoring wells at the INEEL, and presents the advantages and disadvantages of applying the technique to the WAG 10 groundwater monitoring program. Finally, recommendations are made that will aid in the assessment of applying low-flow purging of WAG 10 groundwater-monitoring wells.

C-2. MONITORING WELL PURGING TECHNIQUES

This section describes traditional and low-flow purging techniques used to purge groundwater-monitoring wells prior to sample collection. For purposes of discussion, traditional purging is defined as the removal of a fixed number of borehole volumes (typically, 3 to 5) from a well prior to sampling. Low-flow purging indicates that the pumping rate is set such that there is negligible drawdown (in most cases < 0.1 m) of water inside the well casing during purging. This technique is also termed "minimal drawdown." Each purging technique is summarized in the following subsections.

C-2.1 Traditional Purging

The traditional method of purging groundwater-monitoring wells prior to sampling typically requires the removal of 3 to 5 borehole volumes while periodically measuring groundwater stabilization parameters. A borehole volume is commonly defined as the water standing in the well casing prior to purging, and is calculated by multiplying the cross-sectional area of the well by the height of the water in the casing. This method is widely practiced, and is based on guidelines provided by the U.S. Environmental Protection Agency (EPA 1986). In general, the flow rate is not limited by regulations, and in many cases, the flow rates greatly exceed that of flow into the well bore from the surrounding aquifer. Typically, a minimum of 3 borehole volumes are removed, and if parameters have stabilized, then the well is sampled (Robin and Gillham 1987). If groundwater parameters have not stabilized after pumping 3 borehole volumes, then an additional 2 borehole volumes are removed. No more than 5 borehole volumes are removed and if groundwater parameters have not stabilized after 5 borehole volumes have been removed, the sample is taken along with a record of the purging activity's failure to achieve groundwater parameter stabilization.

Several researchers have determined that high flow rates during traditional purging can have several deleterious effects. These effects include:

- Induced groundwater sample turbidity due to turbulent flow around the well bore, which can cause the entrainment of aquifer solids that may contain contaminants of concern (primarily, metals). The presence of these solids will result in sample concentrations that are biased high. To minimize this effect, it is common practice to filter groundwater samples prior to laboratory analysis. Filtering these samples may remove colloids (i.e., secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials; and viruses and bacteria) that are naturally occurring in the groundwater system; hence, the filtered sample concentrations may be biased low (Puls and Powell 1992).

- Large amounts of potentially contaminated purge water, which typically requires treatment, handling, and disposal.

- Damage to the filter pack and annular seal, decreasing the life of the well.

- Diluting or averaging effects across the screen length and possibly further spreading contaminants in the aquifer.

- Dewatering of low-yield wells, which can cause jetting of formation water into the well bore, causing agitation and aeration, which can affect contaminant concentrations (Giddings 1983).

- Large amounts of time and expense spent pumping purge water.

C-2.2 Low-Flow (Minimal Drawdown) Purging

The low-flow purging technique is based on the idea that groundwater can be pulled through the screened interval of a well with minimal disturbance of the overlying stagnant water column (i.e., minimal drawdown). This technique was developed in the late 1980s and early 1990s in an effort to provide a more scientific approach to obtaining representative groundwater samples (Puls and Barcelona 1995).

Low–flow purging requires that a dedicated pumping device be placed within the screened interval of a monitoring well and pumped at a rate (generally <1L/min) such that very little to no drawdown is observed during pumping. The actual pumping rate is dependent on site-specific and well-specific hydrogeology. Most guidance concerning low-flow purging suggests that groundwater parameters should be measured periodically during purging (Barcelona, Wehrman, and Varljen 1994; Gibs et al. 2000). After these parameters have stabilized, then the well is ready to be sampled. Other workers suggest that groundwater stabilization parameter measurements are unnecessary and that an equivalent of twice the volume of the pumping apparatus (e.g., pump, tubing, etc.) should be removed prior to collecting a groundwater sample (Shanklin, Sidle, and Ferguson 1993). This practice is based on comparative studies of samples generated by standard and low-flow purging techniques. The researchers findings suggest that only the upper portion of the water standing in a well becomes stagnant. Therefore, the water in the screened interval represents groundwater flowing through the well and has no direct contact with the atmosphere (Powell and Puls 1993).

Implementation of low-flow purging includes the following basic requirements:

- Sampling devices must be dedicated. Bailers and portable pumps can disrupt the water column and stir up sediment in the well casing, resulting in the mixing of stagnant and fresh groundwater. It may take 24–48 hours for water in the well to re-equilibrate (Kearl, Korte, and Cronk 1992; Puls and Paul 1995).

- Pump intake must be located within the screened or open borehole interval of the monitoring well (Puls and Barcelona 1995).

- Purge flow rates must be regulated at a very low rate in order to cause little to no drawdown in the well. This recommended rate is less than 1 l/min. However, it is dependent on site-specific and well-specific hydraulics. Hence, it must be determined on a well-specific basis by comparing drawdown in a particular well to flow rates. The purging rate is determined by finding the lowest practical flow rate that causes little to no drawdown in the well.

- Placement depth of the sampling device must be evaluated carefully by identifying zones within the screened or open borehole with high transmissivity or contaminant concentrations (Gibs et al. 1993; McCarthy and Shevenell 1998; and Martin-Hayden 2000).

- Finally, it is recommended that short screen lengths (~1m) be utilized to minimize the effects of mixing and dilution of groundwater along the well bore (Puls and Barcelona 1995).

C-3. SUMMARY OF INEEL STUDIES

The purpose of this section is to present studies that have been conducted at the INEEL related to the evaluation of low-flow purging and sampling technologies. These studies, which are detailed in the following subsections, include *Micropurge Evaluation Results for Test Area North* (Neher and Wood 1997), *An Evaluation of Low Flow Sampling Technology* (Shanklin 2001), *Concentrations of Tritium and Strontium-90 in Water from Selected Wells at the Idaho National Engineering Laboratory After Purging One, Two, and Three Borehole Volumes* (Bartholomay 1993), and *Evaluation of Devices for Sampling Volatile Organic Compounds from Deep Groundwater Wells at the Idaho National Engineering Laboratory* (Marts, Wood, and Bishop 1991).

C-3.1 Neher and Wood 1997

The purpose of this study was to evaluate the comparability of low-flow purging and sampling to traditional purging and sampling techniques at the INEEL's Test Area North (TAN) facility (Neher and Wood 1997). This evaluation also was intended to serve as an initial evaluation of low-flow sampling for the INEEL.

Analysis of historical groundwater contamination data at TAN resulted in the selection of trichloroethylene (TCE) and strontium-90 concentrations for use in this comparative study of low-flow versus standard purging techniques. Four wells were selected for use in this study. The wells represent different zones of the TAN groundwater TCE plume. They included TAN-09, -12, -20, and -DD2. Pump intake depths were determined by using a combination of well completion information and geophysical logs. Depth to groundwater in these wells was measured at about 200 ft below ground surface (bgs). Dedicated electrical submersible pumps were used to purge and sample the wells in this study. During low flow purging, flow rates did not exceed 1gal/min. Flow rates during standard purging ranged from 4.2 to 10 gal/min. Also during low-flow purging, purge volumes ranged from 10.5 to 15.4 gallons. In contrast, standard purge volumes ranged from 233 to 561 gallons. Groundwater stabilization parameters were measured during both purging techniques, and included temperature, pH, specific conductance, and dissolved oxygen (DO).

With the exception of DO, all indicator parameters were stable prior to collecting low-flow samples, and were in general agreement between the two purging techniques. In the case of DO, the value appeared to be strongly affected by pumping rates. The exact cause for this anomaly is not known, but may be attributed to the pumping rate, lithology, or well completion effects.

Problems were encountered prior to project start-up in connection with the use of recently developed Variable Frequency Drive (VFD) submersible pumps in the selected wells. The initial unavailability of these pumps and the problems associated with achieving reliable low flow pumping rates resulted in an 8-month delay of the start of the project. However, it was eventually determined that the pumps would provide a reliable means of achieving the low-flow pumping rates required by the project design.

Sample concentrations of TCE ranged from 3 to 39 μg/l, and strontium-90 results ranged from nondetect to 323 pCi/L. Analysis of the concentrations in groundwater samples collected by each purging technique (low-flow and standard) were directly compared to historical values of TCE and strontium-90 in the sampled wells, and were generally found to be in good statistical agreement. The exception was the TCE and strontium-90 results from TAN-12. Sample results generated by both purging techniques fell below historical values—strontium-90 was not detected in samples generated by either purging technique. A statistical comparison (i.e., student T-test) of the low-flow versus standard purging analytical results also indicated that, in general, there is no statistical difference between the sample concentrations generated by each purging technique. The exception again is seen in the TAN-12 TCE results, which indicate a statistical difference between the purging techniques. Due to the nondetect of strontium-90 in samples generated by the different purging techniques, no statistical comparison was possible.

The anomalous results for TAN-12 samples were attributed to the effects of the large amount of bentonite in the well on TCE and strontium-90 concentrations. The presence of the bentonite in the well indicates poor well construction, poor development, or damage to the well screen or seal.

Overall, low-flow purging results were considered to be consistent with those of standard purging; hence, low-flow purging appears to be an effective means of collecting representative groundwater samples at TAN. The results of the project were intended to establish an initial evaluation of the low-flow purging and sampling technology at the INEEL; however, the authors do call attention to the limitations of the project. Since only TCE and strontium-90 were evaluated in the project, the results and interpretations may not be directly applicable to other areas of the INEEL with differing contaminants of concern. Another limitation is that the use of the VFD pumps may not be practical or even possible in areas of the INEEL with much greater depths to groundwater. The use of low-flow purging should therefore be evaluated on a site-by-site basis at the INEEL.

The report also presents a cost comparison for low-flow versus standard purging at TAN. The authors estimate that approximately $1,260,000 can be saved over a 30-year period through the conversion to a low-flow purging program, given the current sampling plan.

C-3.2 Shanklin 2001

The purpose of this study was to present a review of studies focused on applications of low-flow purging and sampling techniques (Shanklin 2001). The primary objective of the report was to demonstrate that groundwater sampling can be performed more efficiently, groundwater data quality can improve, and the amount of purge water can be reduced by utilizing low-flow purging and sampling techniques at the INEEL.

The report begins with a summary of current well-purging procedures and low-flow purging and sampling design principles. A thorough review of literature related to low-flow purging and sampling was included as an appendix to the report. Thorough discussions of groundwater stabilization parameters and innovations related to low-flow purging and sampling are included as appendixes. Selected case studies of low-flow purging and sampling also were presented. These studies included the U.S. Department of Energy (DOE) Fernald Environmental Management Project, DOE Savannah River Site, DOE Hanford Site, Princeton Plasma Physics Laboratory, Lawrence Livermore National Laboratory, the Idaho Nuclear Technology and Engineering Center (INTEC), and TAN. The report ends with a summary of the report contents, conclusions, and recommendations for further evaluation of low-flow purging and sampling at the INEEL.

The Fernald Environmental Management Project (FEMP) project details are summarized in the *Micro-Purge Low-Flow Sampling of Uranium-Contaminated Ground Water at the Fermald Environmental Management Project* report (Shanklin, Sidle, and Ferguson 1995). The experiment was designed to compare concentrations of uranium in groundwater samples collected through conventional purging and low-flow purging techniques. Analysis of the results indicated no measurable difference in concentrations in samples generated by the two purging techniques. Furthermore, groundwater stabilization parameters did not seem to be good indicators that representative groundwater is being removed from a particular well and were not used to determine when to collect a low-flow sample.

The Savannah River Site (SRS) discussion in the report does not include any information specific to low-flow purging. Rather, the information presented describes an innovative purge water management technique that was developed and is being utilized at the SRS. This technology is designated as the Purge Water Management System (PWMS). The PWMS is a closed-loop system for temporarily storing purge water. The system consists of a bladder inside an aboveground storage tank that expands in proportion to the amount of water entering the tank. After indicator parameters have stabilized during purging, the groundwater sample is collected and the purge water stored in the tank is returned to the well through the return system. Hence, wells at which the PWMS is used will not generate investigation-derived waste (IDW), eliminating the need for handling, storage, and disposal of the IDW. This system was approved for use at the SRS by the governing regulatory Agencies in 1996.

The report also includes a discussion of an ongoing evaluation of no-flow and low-flow sampling technologies at the DOE Hanford Site. The evaluation includes 78 of 650 groundwatermonitoring wells at Hanford. The evaluation will test the ability of the different purging technologies to produce groundwater sample data that are comparable to historical data generated using traditional purging techniques.

According to discussion presented in the report, the Princeton Plasma Physics Laboratory (PPPL) is currently utilizing low-flow purging and sampling technology. Using dedicated pneumatic bladder pumps placed within the screened interval, the PPPL expects to realize a cost savings of over $500,000 in a ten-year period.

The report presents a brief discussion of an innovative low-flow and purge water management technology that is being employed at the Lawrence Livermore National Laboratory. This technology is termed the Easy Pump Sampling System, and consists of a disposable sampler that is placed within the screened interval of a well. The upper end of the sampler is attached to an inflatable bladder, which isolates the sample interval from the overlying stagnant water column. Purge water first inflates the bladder and is then routed into the well column above the bladder. No discussion regarding comparability to traditional groundwater purging and sampling is presented in the report.

The report includes discussion of an evaluation of low-flow purging and sampling at the Idaho Nuclear Technology and Engineering Center (INTEC) at the INEEL. The discussion indicates that Pao (2001) recommended the implementation of a low-flow groundwater sampling procedure at the INTEC based on a cost-savings analysis. The analysis predicts a 95% reduction in purge water generation and an associated cost-savings of up to $200,000 per year. Evidently, no field studies comparing low-flow purging and sampling to traditional methods has been performed at the INTEC.

The report indicates that low-flow purging and sampling is currently being successfully implemented at TAN as part of the *in situ* bioremediation project. This practice received verbal approval from regulatory Agencies in 1999. The implementation of low-flow purging and sampling at TAN was preceded by an evaluation of the technology (Neher and Wood 1997).

Based on literature review and selected case studies, the author of the report draws the following conclusions:

- The need for removing large volumes of purge water through the traditional purging method (i.e., three borehole volumes) is not supported.

- The implementation of low-flow purging and sampling at the INEEL will result in significant cost savings through the reduction of IDW and labor.

- The need for conducting studies comparing low-flow purging and sampling technology to traditional purging and sampling methods is not necessary.

- The use of intrusive sampling methods (e.g., bailers, non-dedicated pumps, etc.) may result in non-representative groundwater samples due to the disturbance of the sampling interval.

- Monitoring groundwater stabilization parameters is not necessary in determining when to collect a sample, due to the apparent influences of weather conditions, temperature variations, changes in measuring equipment, pumping rates, and operator performance. (Please note that this is the opinion of the report author [Shanklin] and not the opinion of WAG-10). However, the author does recommend that these parameters still be measured and recorded to document groundwater conditions.

- Collection and analysis of rinsate samples can be reduced through the use of dedicated sampling equipment, which is strongly recommended in the execution of a low-flow purging and sampling program.

- Low-flow sampling will produce groundwater samples that are more stable and representative of aquifer conditions at the INEEL; thus, it should be evaluated for use Sitewide.

- Implementation of a low-flow purging and sampling program at the INEEL should be customized to fit Site-specific and well-specific hydrogeologic conditions and regulatory constraints.

The report also recommends that the following innovative technologies be evaluated for use at the INEEL:

- Aboveground bladder storage of purge water

- Well casing purge water storage

- Mulit-level sock samplers (for use in vertical profiling of contaminants)

- No-flow sampling.

C-3.3 Bartholomay 1993

Although this study did not specifically evaluate the effectiveness of low-flow purging in groundwater-monitoring wells at the INEEL, the results indicate that the removal of three borehole volumes of water is not necessary to obtain representative groundwater samples from deep aquifer wells at the INEEL (Bartholomay 1993).

The purpose of this study was to evaluate the effects of purging one, two, and three borehole volumes on tritium and strontium-90 concentrations in 11 groundwater-monitoring wells at the INEEL. The wells utilized in this study included: Site-9, -14, and -19, TRA Disposal, and USGS-38, -59, -82, -83, -107, -110, and -119. These wells are located primarily in the southern region of the INEEL. Depth to groundwater in these wells ranged from 266 ft to 606 ft bgs, and well depths ranged from 657 to 1,267 ft bgs. Six of the wells had open-hole completions, and the remaining wells were screened. The exception is USGS-82, which possesses both screened and open borehole completions. In three wells with open borehole completions, the pumps were set above completion depth. All other pump depths were set within completed intervals (i.e., within the open borehole or screened interval). Purge rates ranged from 3 to

25 gal/min, and averaged 10.7 gal/min. Groundwater stabilization parameters were recorded in the field after removal of each borehole volume in each well. These parameters included pH, specific conductance, and temperature. All field parameter values were within 10% of each reading. Each well required more than one hour to purge one borehole volume of water.

After each purging event, samples were collected and submitted for laboratory analysis. The effects of purging one, two, and three borehole water volumes on tritium and strontium-90 values were evaluated using a statistical comparison. Concentrations of these radionuclides after removing one and two borehole volumes were individually compared to concentrations after purging three borehole volumes. These analyses indicated that concentrations of tritium and strontium-90 were not measurably affected by purging one, two, and three borehole volumes.

Although the report concludes that it is not necessary to purge three borehole volumes in order to obtain representative groundwater samples, the author recommends that the practice of purging three borehole volumes prior to sample collection should continue to "ensure consistency in the data base" (Bartholomay 1993).

It is worth repeating that this study did not specifically evaluate low-flow, minimal drawdown purging. In addition, the study did not include contaminants that may be more sensitive to the effects of stagnation in the well column (e.g., volatile organic compounds [VOCs]). Thus, conclusions drawn by the study may not apply to all areas of the INEEL, which have different contaminants of concern.

C-3.4 Marts, Wood, and Bishop 1991

This study was designed to evaluate the effectiveness of different pump types in the collection of VOC samples at several wells at the INEEL (Marts, Wood, and Bishop 1991). The study was motivated by the need to know whether different devices affected VOC concentrations during sampling (e.g., loss of VOCs through stripping, aeration, etc.). The study was not designed to evaluate low-flow purging and sampling technologies. The standard purging technique of removing a minimum of three borehole volumes from the monitoring wells was used in this study. Furthermore, groundwater levels within the sampled wells were not monitored during purging. Therefore, the results of the study cannot be used to support any argument for or against the implementation of low-flow purging and sampling practices at the INEEL. However, the results presented in the report may be useful in the selection of groundwater pumps for use in low-flow purging and sampling.

The study evaluated four different devices for the collection of groundwater samples for VOC analysis. The pump types included a gas-driven piston pump, centrifugal pump, bailer, and bladder pump. The wells utilized in the study included TAN Disposal-1, TAN Disposal-2, and USGS-90. Depths to groundwater ranged from 207 and 198 ft bgs at TAN Disposal-1 and TAN Disposal-2 wells, respectively, to 585 ft bgs at USGS 90, which is located at the Radioactive Waste Management Complex (RWMC). The VOCs measured in this study included CCl_4, TCE, 1,1,1-trichloroethane (TCA), and tetrachloroethylene (PCE). After purging a minimum of three borehole volumes, each well was sampled using the four sample devices listed above.

Several criteria were employed in comparing the VOC results of the samples collected by the four different devices listed above. These criteria included bias (i.e., percent VOC loss), precision (i.e., variance), logistics (i.e., ease of use), and capital cost. Each criterion was assigned a subjective weighting factor. The most important criterion was bias, and was assigned a weighting factor of 45. Precision, logistics, and capital costs were assigned weighting factors of 25, 20, and 15, respectively.

The analysis presented in the report indicated that the gas piston pump, the centrifugal pump, and the bailer were nearly equal in producing statistically similar groundwater samples. The bladder pump performance was nowhere near as favorable as the other sampling devices, and was not recommended for widespread use at the INEEL. The overall conclusion of the report was that the centrifugal pump was the most favorable sampling device for widespread use at the INEEL.

C-4. POTENTIAL ADVANTAGES OF LOW-FLOW SAMPLING

Advantages of applying low-flow sampling at the INEEL include:

- Cost savings are realized due to reduced labor, handling, treatment, and disposal of purge water
- Improved data quality through the reduced (or eliminated) need for sample filtration, reduced mixing of water in the well column, and minimized disturbance of particulates in the well (Puls and Powell 1992; Gibs et al 1993)
- Sample variability (affected by accuracy and precision) can be reduced as a result of reduced stress on the formation, reduced mixing and dilution of analytes, and reduced potential for sample agitation, aeration, and degassing or volatilization
- Greater ability to detect and resolve contaminant distributions within an aquifer
- Minimization of the damaging effects of high flow rates on well filter packs and annular seals, thereby increasing the useful life of wells
- Reduced exposure of field personnel to potentially contaminated purge water.

C-5. POTENTIAL DISADVANTAGES OF LOW-FLOW SAMPLING

Potential disadvantages of implementing a low-flow purging program include:

- Low-flow purging may not be practical in wells that penetrate deep aquifer due to technology limitations
- Concern that new analytical results generated by low-flow purging will not be comparable with historical data at the INEEL
- Resistance to change on the part of sampling practitioners and regulatory agencies
- Concern that new data will indicate a change in conditions and trigger an action
- Higher initial capital costs (if new pumping devices are required) and increased training needs
- The sampling may not be effective in poorly constructed, poorly developed, or damaged wells.

C-6. CONCLUSIONS AND RECOMMENDATIONS FOR WASTE AREA GROUP 10

The studies presented in this document represent a large base of scientific research supporting low-flow purging as a cost efficient means of collecting decision quality groundwater data. However, researchers stress the importance of the proper application of relatively new groundwater sampling techniques at various sites (Barcelona 2000; Galloway 2000; Stone 1997). Nevertheless, the advantages of better quality data, increased efficiency, and cost savings provide a strong motivation to evaluate the use of low-flow purging at WAG 10 wells.

An important consideration in the implementation of a low-flow purging program is the extreme groundwater depths (e.g., >500 ft bgs) found in WAG 10 wells, which may present a practical limitation of using the technique. The single most important problem is achieving low flow rates while lifting groundwater upwards from these great depths. No study presented in the literature has addressed the problem of achieving minimal drawdown in groundwater wells penetrating deep aquifers. A possible exception is the United States Geological Survey (USGS) study summarized in this document in which purge flow rates averaged 11 gal/min (Bartholomay 1993). Given the high transmissivity of the Snake River Plain Aquifer (SRPA), these flow rates may result in little to no drawdown in the wells during purging. However, water levels were not monitored to assess drawdown in the wells during purging in the study.

Groundwater pumping technology does exist that will achieve low flow rates at greater depths (i.e., Grundfos® 4" VFD pumps). These pumps, as reported by the manufacturer, are capable of lifting groundwater from 524 ft bgs at flow rates ranging from 100 ml/min to 50 gal/min (see Grundfos URL in References section). The SRPA beneath the INEEL is comprised of a layered stack of pahoehoe basalt flows intercalated with sedimentary deposits. The areas between the basalt flows are highly transmissive, and groundwater can move through these zones at much greater velocities than that of a typical clastic aquifer. Therefore, flow rates less than 1 L/min may not be required in order to achieve minimal drawdown in wells penetrating the SRPA. Thus, today's technology may support low-flow purging of groundwater in these deeper wells.

As mentioned above, no studies evaluating the effectiveness of low-flow purging in deep monitoring wells have been conducted at the INEEL. Therefore, there is no reason to reject the implementation of low-flow purging in these deeper wells; a thorough evaluation of low-flow purging in areas of the INEEL with depths to groundwater greater than 500 ft is recommended. This type of evaluation may not be appropriate for WAG –10, due to the paucity of historical contaminant data (Note: WAG 10 does not include large areas of contamination). Rather, it is recommended that an evaluation be conducted at WAGs where groundwater contamination exists, and therefore an historical database exists to provide comparison of traditional to low-flow purging techniques. If an evaluation of low-flow purging at WAGs with contaminated groundwater proves effective, then implementation of such a program at WAG 10 may be supported.

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